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Design and Evaluation of an Environmental Science Curriculum for Secondary Students

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Design and Evaluation of an Environmental Science Curriculum for Secondary Students

by

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Table of Contents

Chapter One

Introduction to the Study

Environmental education is becoming an increasingly important component of secondary science education as our society attempts to minimize the exploitations and damaging actions of humankind on the earth. Environmental education has evolved primarily from environmental consciousness in the 1960s to an environmentally active focus in the 1990s. This project examined the effectiveness of an environmental education curriculum that focuses on improving environmental behaviors and attitudes as well as knowledge.

The review of the literature for this project indicates that responsible environmental behaviors are linked to four types of environmental education categories. These categories are hierarchical and include: 1) ecological concepts, 2) conceptual awareness, 3) issue investigation and evaluation, and 4) environmental action skills (Disinger, 1993). A review of environmental education curricula provides a wide variety of activities in all four of the above listed categories.

Information documenting the relationship between the acquisition of environmental knowledge and behavioral change as a result of participating in community based environmental activities is less evident. Therefore, this project attempted to investigate the relationships between participation in community-based environmental activities and tenth-grade students' knowledge and attitudes toward environmental issues.

During the spring semester of 1995 forty-five tenth-grade biology students at a private urban high school were pretested to assess their initial environmental concept knowledge and their initial environmental attitudes. These students were subsequently exposed to a three-week introduction to environmental concepts and to techniques for investigating environmental issues. Students were simultaneously given a variety of issues to investigate. An additional four hours of time were required of each student to participate in a community service related to an environmental concern. They submitted a written report of their work which included background research, method of participation, results and conclusions on the effect of their project on the environment. Following these experiences, a posttest was administered to assess any change in students' environmental knowledge or attitudes.

Effective environmental education encourages the active participation of students in environmental improvement. The results of this investigation could assist educators in the selection of appropriate environmental activities for use with high school students.

Definitions of Common Terms

Authentic assessment--assessment that measures cognitive and affective change through a variety of appropriate and meaningful activities (Klein & Merritt, 1994).

Conceptual awareness in environmental science--knowledge of how individual and collective behaviors influence the quality of the environment (Disinger, 1993).

Constructivist teaching--a method of instruction that incorporates real-life problems, student-centered instruction facilitated by an instructor, productive group interaction and authentic assessment (Klein & Merritt, 1994).

Ecological concepts--knowledge of ecosystems, populations, limiting factors, biogeochemical cycling, abiotic and biotic components, homeostasis and other related topics.

Environmental action skills--knowledge and skills to resolve environment-related issues (Disinger, 1993).

Environmental education--a curriculum of ecology concepts, issue analysis skills, and environmental action skills aimed toward responsible environmental behaviors.

Issue investigation in environmental science--knowledge and skills to permit individuals to analyze issues and evaluate solutions to environmental concerns (Disinger, 1993).

Locus of control--a person's feeling of effectiveness or a measure of the amount of control over events.

Chapter Two

Review of the Literature

The review of the literature in environmental education covered several topics; history of environmental education, environmental sensitivity, environmental citizenship, guidelines for developing environmental education curricula, and curriculum design. Other areas that were reviewed included action research, integration of environmental science with other courses, and current environmental curriculum materials.

History of Environmental Education

Environmental education dates back to the Greek philosophies of Plato and Aristotle and continues to the frameworks outlined by scientists, researchers and educators in Project 2061 (American Association for the Advancement of Science, 1993), which address current environmental issues. Contemporary views can be traced back to historically significant environmental scholars such as Louis Agassiz, who wrote "study nature, not books" in the mid-1800s and Wilbur Jackman who encouraged the use of direct observation or hands-on activities in Nature Study for the Common Schools in 1891 (cited in Disinger, 1993).

Conservation education began during the 1800s in Britain and America, becoming a government focus in America during the 1930s. This movement helped educate the general public about the effects of over-farming the Mid-Western plains. Simultaneously the progressive education movement surfaced, integrating environmental education into the public-school curriculum. Evidence of growing public concern over environmental issues is found in the work of Leopold, who addressed the need for more substantive environmental education in A Sand County Almanac in 1949.

The first long-range conservation effort began in 1948 with the founding of the International Union for the Protection of Nature (IUPN), today known as the International Union for Conservation of Nature (IUCN). The IUCN publishes and continues to maintain the Red Data Books, which list endangered species worldwide.

The 1960s ushered in the Environmental Movement with the formation of grassroots clubs and societies whose aim was to increase environmental consciousness. In 1962 Rachel Carson published Silent Spring, while Buckminster Fuller proposed the concept of Spaceship Earth in 1965.

During the 1970s many groups held international conferences addressing environmental problems. In 1980 the Global 2000 Study was presented to the President of the United States. This study addressed the planet's natural resources as projected for the year 2000. An estimated

80,000 non-governmental groups worldwide worked on conservation efforts during the mid-1980s. The publication of the World Conservation Strategy in 1988 and the call for a worldwide convention on a Global Strategy for the Conservation of Biodiversity in 1990 united individuals throughout the world on environmental protection issues.

Environmental Sensitivity and Citizenship

An area of concern in environmental education is environmental sensitivity. This idea promotes awareness of the Earth's environment and participation in environmental preservation activities. Peters-Grant and Peterson (cited in Volk, 1993) address environmental sensitivity in relation to teaching environmental education and note that individuals who participate in outdoor experiences such as hiking, hunting and fishing over an extended period of time tend to exhibit heightened environmental sensitivity. "The development of environmental sensitivity seems to be longitudinal, cumulative, and directly related to experiences in outdoor settings" (Peterson, 1982 cited in Ramsey, 1993, p. 36). Researchers indicate that books, videotapes, music, art, photography and other materials can help develop in learners a positive attitude toward the environment. Knowledge of environmentally active individuals such as Rachel Carson, Ding Darling, Jane Goodall and John Muir can lead to increased environmental awareness.

In addition to general suggestions, the literature identifies many specific concepts related to environmentally helpful behaviors. Bioregionalism and ecofeminism are two concepts that may help to develop environmental sensitivity (Corcoran & Sievers, 1994). Bioregionalism is the belief that individuals will become more respectful and biologically conservative after developing an awareness of the area in which they live. Ecofeminism proposes that there is a relationship between "abuse of nature and oppression of women" (Cocoran & Sievers, 1994, p.7). It argues that awareness of feminine intuition and feminine perspective on ecological crises could help create more positive behaviors in a male-centered culture.

The literature also states that responsible citizenship or positive environmental activity is best promoted by students having a knowledge of citizenship skills and of methods for practicing them. These skills include ecomanagement activities such as litter removal and planting sea oats; persuasive activities, or writing and talking about the environment; consumer activities, such as boycotts or reduced use of certain products; political action, such as lobbying or campaigning; and legal action that helps to rectify environmental issues (Volk, 1993).

Training students to participate in environmental activities is an important aspect of environmental education. Leeming (1993) analyzed several research studies in environmental education that measured changes in environmental behaviors. In three of the five studies training subjects for pro-environmental behaviors produced improvement in knowledge, attitude and behavior.

Environmental education has also focused on the tendency of individuals to participate in environmental activities. One important determining factor in an individual's engagement in environmentally responsible behavior is that person's locus of control, or feeling of effectiveness (Hines cited in Volk, 1993). Those individuals with an internal loci of control feel that they have some control over events in their lives, while those with external loci of control feel that events are controlled by forces outside themselves. A person who feels powerless may act less responsibly. An internal locus of control is developed by practicing citizenship skills.

Guidelines for Developing Curricula

Environmental education curricula can be developed using different models of environmental principles. For example, many naturalists teach that the better an ecosystem is understood, the less likely it will be destroyed. The Sengalese conservationist Baba Dioum noted, "In the end, we will conserve only what we love, we will love only what we understand, we will understand only what we are taught" (cited in Wilson, 1992, p. 320). Therefore, a primary objective of environmental education today is to help citizens become environmentally aware and active. This objective is explicit in the twelve principles of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Conference held in 1975 and 1977. These principles were developed to focus and guide the field of environmental education (cited in Disinger, 1993). (See Appendix A.)

In response to growing environmental concerns, American educators have developed many environmental education curricula for use at all academic levels.
An educationally sound environmental education curriculum will produce several measurable characteristics in students.
J. M. Hines, H. R. Hungerford and A. N. Tomera analyzed student behavior and found that individuals who exhibit responsible behavior on a broad range of environmental problems have several characteristics in common. These characteristics include:

> knowledge of relevant environmental concepts, knowledge of environmental problems and issues, concern for the quality of the environment, knowledge of action strategies that may be used for resolving an issue, belief that their actions can make a difference, commitment to taking action, and experience in action-based activities. (cited in Disinger, 1993, p.37)

Researchers confirm that individuals must not only have knowledge of environmental issues but also the ability to analyze issues. Attitudes and values focused on taking action are required before individuals act responsibly.

Based upon research on responsible environmental behavior, H. R. Hungerford concluded that curricula should stress a hierarchical approach to environmental activities. The activities include:

> Ecological concepts: knowledge of ecosystems, populations, limiting factors, biogeochemical cycling, abiotic and biotic components and homeostasis,
> Conceptual awareness: knowledge of how individual and collective behaviors influence the quality of the environment and subsequently the quality of life which might lead to issues that must be resolved through investigation, evaluation, decision making and action,
> Issue investigation and evaluation: knowledge and skills to permit learners to investigate issues and evaluate solutions, and
> Environmental action skills: knowledge and skills to resolve environment-related issues and participation in implementation. (cited in Disinger, 1993, p.37)

Researchers conclude that responsible behaviors will persist only after individuals are exposed to all four levels of activities. Furthermore Sia, Hungerford and Tomera found that the quality of students' environmental actions is enhanced when they have also employed issue analysis and investigation skills (cited in Disinger, 1993).

Curriculum Design

Designing engaging environmental education curricula and appropriate assessment techniques is critical to effective teaching. According to the Virginia State Department of Education environmental education curriculum guidelines of 1974, a program that meets the goals of environmental education will be participant-centered.

> Student participation should be encouraged by allowing the students to help determine the nature of the experiences in which they are involved and the experiences should be activity centered. Environmental experiences should immerse students in the "real" world which they can see, touch, and smell. (Klein & Merritt, 1994, p. 20)

Klein and Merritt (1994) propose the use of constructivist teaching as a useful model of instruction for environmental education. They suggest four components of a successful constructivist unit: (a) introduction of a real-life problem by the students or teacher, (b) student-centered instruction facilitated by the teacher, (c) productive group interaction during the learning process, and (d) authentic assessment and demonstration of student progress. This method of instruction incorporates the four outcomes of environmental education: knowledge, skills, dispositions and environmental behaviors stated in the UNESCO conference in 1975 and 1977 (cited in Disinger, 1993).

In view of the need to make environmental education more participant-centered, the inclusion of authentic, student-selected assessment is encouraged (Klein & Merritt, 1994). According to Jonassen, Chaille and Britain, authentic assessment has been used successfully in environmental education to measure both cognitive and affective skills (cited in Klein & Merritt, 1994). Students are responsible for participating in authentic, meaningful tasks and developing and defending their points of view.

Constructivist teaching and authentic assessment can help prepare students for real-world problems. Investigations into environmental issues, individual and group assessments, mock presentations, environmental monitoring projects, participation in local, state or government environmental activities, and portfolios are examples of authentic environmental activities. As Heibert and Calfee noted, "citizens in the 21st century will not be judged on their ability to bubble in answers on test forms" (cited in Klein & Merritt, 1994, p. 21).

Action Research

An approach to studying the effectiveness of teaching strategies is action research. The development of an engaging environmental science curriculum is supported by Elliott's definition of action research. In his text Action

Research for Educational Change (1991), Elliott considers "teaching, educational research, curriculum development and evaluation as integral aspects of an action research process. Action research is a reflective practice that uses empirical data as a basis for reflectively improving teaching practices" (p.52). Teacher improvement and improvement of teaching coincide as instructors involve all the perceptions of students, parents, other teachers and administrators in making changes.

Action research is described by Hitchcock and Hughes as "inquiry conducted into a particular issue of current concern, usually undertaken by those directly involved, with the aim of implementing a change in a specific situation" (p. 7). Action research helps to solve problems and justify the solutions in an inclusive and reliable manner.

Integration within the Curriculum

Integration of environmental education with other disciplines is recommended by many educators (McKeown-Ice, 1994; Lisowski & Williams, 1993). Environmental education has a natural connection with the disciplines of biology, mathematics, chemistry, geography and the humanities. As students study the natural environment through scientific techniques, many concepts are interwoven into an integrated curriculum. Key ideas, which illustrate the merging of disciplines, include the distribution and change of biotic and abiotic factors. The study of the migration of organisms, patterns of vegetation, weather, landscape changes due to natural forces and human interactions with the planet are all related to environmental science. This integration is encouraged by literacy standards established by the American Society for Testing and Measurement (ASTM), by teacher certification standards, by state environmental initiatives and by national frameworks for geography and science education, all of which endorse the principle of integrated learning.

Curriculum Materials

Environmental education curriculum materials address a wide variety of issues and include an assortment of teaching methods. Many special interest groups, industries, concerned citizens, and governmental agencies have developed materials for environmental education. Most curricula promote broad awareness of issues and environmental conditions, develop skills and habits associated with critical thinking and problem solving, promote understanding of foundational knowledge related to the natural environment, and focus attention on global conditions in need of responsible human action. The National Science Teachers Association sponsored the production of the text, Environmental Education, Teacher Resource Handbook (Wilke, 1993), which provides teachers with current resources and environmental education information. Several selected materials that are appropriate for high school students are described in Appendix B of this study.

Summary

Current environmental education includes a curricular approach that stresses knowledge of environmental concepts, conceptual awareness, investigation and evaluation of environmental issues, and the practice of environmental action skills, all of which integrate the use of multiple resources. The design of an environmental education curriculum with this scope and sequence has been shown to develop in students the ability to initiate and participate in environmentally positive behavior. The addition of an action research orientation by the classroom teacher is useful in monitoring student progress and in modifying the curriculum as it is implemented.

Chapter Three
Methodology

The preceding review of the literature associated with environmental education indicated that students should exhibit responsible environmental behaviors as a result of their education. These behaviors should occur after students learn substantial environmental content, experience issue evaluation skill practice, and engage in environmental action activities. Other researchers stated that individuals would become more respectful of the environment after developing more awareness of their surroundings. Further, researchers advocated that student participation be encouraged in environmental education and that students be allowed to select the activities in which they will be involved.

Purpose

Based upon these findings, this project focused on developing an environmental education syllabus and content for high school biology students. This content was designed for a three-week period and incorporated both national science objectives (American Association for the Advancement of Science, 1993) and the Florida State Science Curriculum

Framework (Florida Department of Education, 1993). As part of the instructional unit, students were to have completed a community environmental project. Content knowledge was first assessed by pretest and later assessed by both a posttest and an analysis of students' environmental action projects.

Population and Procedure

Study participants came from three sections of regular tenth-grade biology students who had not been exposed previously to a formal environmental education curriculum. These students were enrolled in a private college-preparatory religiously-affiliated high school in Jacksonville, Florida, and were taking a year long biology course designed for average ability students. The school had identified social action projects as important to student learning. The sixteen students in the study completed both pretest and posttest while other students did not, due to absence or class scheduling.

A pretest was used to measure students' knowledge, environmental sensitivity, attitudes, values, and behaviors. The knowledge survey was a questionnaire, using short answer and multiple choice questions, related to environmental topics such as trophic levels and nutrient cycles. Environmental sensitivity was measured using a series of questions, answered on a Likert-type scale, and with short answers related to personal views on environmental issues.

(See Appendix C for environmental knowledge and attitude survey questions.)

Following the administration of the pretest, students experienced a three-week introductory unit which included the following topics: ecosystem components, trophic levels, natural cycles and human influences on the environment. Students analyzed case studies of environmental issues in order to practice decision-making skills related to those studies. (See Appendix D for Content Outline.)

During the three-week environmental unit, students were also required to participate in a community action project. The project was chosen by each student to enhance some aspect of the environment in their community. A short write-up of their work along with proof of their participation was required. (See Appendix E for Environmental Action Project Guidelines.)

A posttest, identical to the pretest, followed the completion of the environmental unit. This posttest was used to measure changes in knowledge and attitude. The results of the pretest and posttest were compared and analyzed.

Curriculum Objectives

The objectives for the environmental curriculum used in this research were based upon recommendations from Project 2061, Benchmarks for Science Literacy (American Association for the Advancement of Science, 1993) and Science for All

Students, Florida Science Curriculum Frameworks, A Guide for Curriculum Planners (Florida Department of Education, 1993.)

The following are examples of suggested ecological goals that high school students should be able to attain after studying an ecology unit:

1. Given population and other pertinent data at an ecosystem, students can determine cause and effect relationships (predator-prey, climate-population), trace the flow of energy and the cycling of matter through the food web, and predict the impact of introducing new species into an ecosystem.
2. Students can give an example of a biological situation that clearly demonstrates that matter recycles and energy does not.
3. Students can formulate defensible scientific hypotheses regarding the consequences of losing biodiversity.
4. Students can successfully participate in role-playing or case studies involving the consequences of human impact on the environment. They can present evidence supporting or refuting both sides of environmental conservation and economic development issues.
5. Students can engage in classroom activities that allow the development of a sense of responsibility to future generations to conserve what is left of Earth's

natural resources (Florida Department of Education, 1993, pp.31-32).

The Benchmarks for Science Literacy, Project 2061 suggest the following ecological goals should be achieved by 12th grade students.

1. Students should know that the variation of organisms within a species increases the likelihood that at least some members of the species will survive under changed environmental conditions, and a great diversity of species increases the chance that at least some living things will survive in the face of large changes in the environment.

2. The decisions of one generation both provide and limit the range of possibilities open to the next generation.

3. Agricultural technology requires trade-offs between increased production and environmental harm (American Association for the Advancement of Science, 1993, pp. 105,163,186).

Using the recommendations from Project 2061 and the Florida Science Curriculum Frameworks, the following objectives were implemented for the three-week environmental study unit in the tenth-grade biology course used for this project. These objectives operationalized the previously mentioned ecological goals. The textbook <u>Biology</u>

(Essenfeld, Gontang, & Moore, 1994) was used as a resource by teacher and students.

1. Explain the relationship between ecology and the biosphere.

2. Recognize abiotic and biotic factors in an environment and distinguish them from each other.

3. Recognize the components of an ecosystem and the differences among ecosystems.

4. Explain the relationship between niche and ecosystem.

5. Recognize the characteristics of the earth's major biomes.

6. Relate trophic levels and food webs to the flow of energy in a community.

7. Explain the concept of biomass and its relationship to ecological pyramids.

8. Describe the biotic and abiotic processes involved in the water cycle.

9. Describe how photosynthesis and respiration form the carbon and oxygen cycles.

10. Describe the methods by which nitrogen can be cycled between organisms and the abiotic environment.

11. Recognize the impact of humans on ecosystems and analyze and develop plans to correct negative human impacts.

These content outcomes were reinforced through interactive laboratory activities. (See Appendix F for Lab Activities.)

Community Action

As they experienced classroom activities, students simultaneously participated in a community environmental activity requiring at least four hours of their out-of-school time. Sample activities for this component included cleaning up the beach, volunteering at a state park, recycling paper, cleaning up a local neighborhood, participating in a beautification project, participating in local environmental action groups such as BEAKS, Sierra Club, RiverWatch, Guana River Walk, or becoming involved in other local environmental issues such as Rodman Reservoir, mass transit, and manatee protection.

After selecting a topic, students conducted research and included background information regarding their environmental issues. A detailed account of a plan of action was developed, along with discussion of the justification of the plan of action. Students then made observations on the activity and included both environmental and personal responses. Students noted the condition of the environment before and after their activity and commented on their feelings about the environment and their participation in the activity. Documentation of student participation was made on a community service sheet, completed and verified by an outside observer, and included in the student's results. In their conclusions, students discussed the effects of their project on the environment and their plans for future work. (See Appendix E for Environmental Action Project.)

Evaluation of the community service project consisted of a point allocation for each section of the assignment. Satisfactory completion of the project earned fifty points. In addition to these activities, students presented their projects to each other in class for information and discussion.

Posttest and Analysis of Data

Students retook the pretest as a posttest. It was assumed that the results of the two tests would reflect any changes which may have occurred in knowledge, attitude, values or behaviors. A comparison of the mean of the pretest and posttest was conducted to measure content knowledge changes. Scores on the pretest and posttest attitude questions were compared and used to measure attitude change. The standard deviation, frequency distributions of scores and a t-test was conducted to determine the significance of the differences between pretest and posttest knowledge results. Frequencies of answers on pretest and posttest attitude questions and of the frequencies of environmental activities on the environmental projects were also determined.

Chapter Four

Results

The results of this study include pretest and posttest knowledge scores, their means and standard deviations and the frequencies of scores. A t-test for pretest and posttest knowledge scores was also conducted to compare the mean scores.

Sixteen tenth-grade regular biology students were pretested and posttested for knowledge of environmental concepts. The questions included knowledge of environmental terms, trophic level identification and biogeochemical cycles. Responses to knowledge questions were short answer and multiple choice.

The individual scores, mean and standard deviation for the pretest and posttest knowledge survey are recorded in Table 1 and the frequencies of pretest and posttest knowledge scores are recorded in Figure 1. The numbers of missed and correct pretest and posttest knowledge items are displayed in Table 2.

A t-test was performed for pretest and posttest scores comparing knowledge change in this study ($t=11.61$, $df=15$). The difference between the two means was significant at the

.001 level, which indicated an increase in student knowledge.

Response patterns are listed for attitude questions showing pretest and posttest attitudes on a Likert-type scale in Table 3. The numbers of students choosing activities that would help the environment are listed for the pretest and posttest. (See Table 4) The numbers of students choosing activities that would hurt the environment are listed for the pretest and posttest. (See Table 5)

As part of the requirement for completion of this curriculum, students were required to participate in a community service project for environmental improvement. Students were allowed to select their own projects and were required to work a minimum of four hours. Table 6 indicates the projects and the number of students that participated in each project.

Table 1

Knowledge Scores for Environmental Knowledge Survey

Student Number	Pretest	Posttest
1.	5	14
2.	6	16
3.	9	16
4.	9	15
5.	8	13
6.	5	16
7.	5	12
8.	2	14
9.	5	15
10.	6	16
11.	4	11
12.	4	14
13.	12	14
14.	7	15
15.	10	14
16.	2	12
M	6.18	14.18
SD	2.72	1.5

Total possible = 16

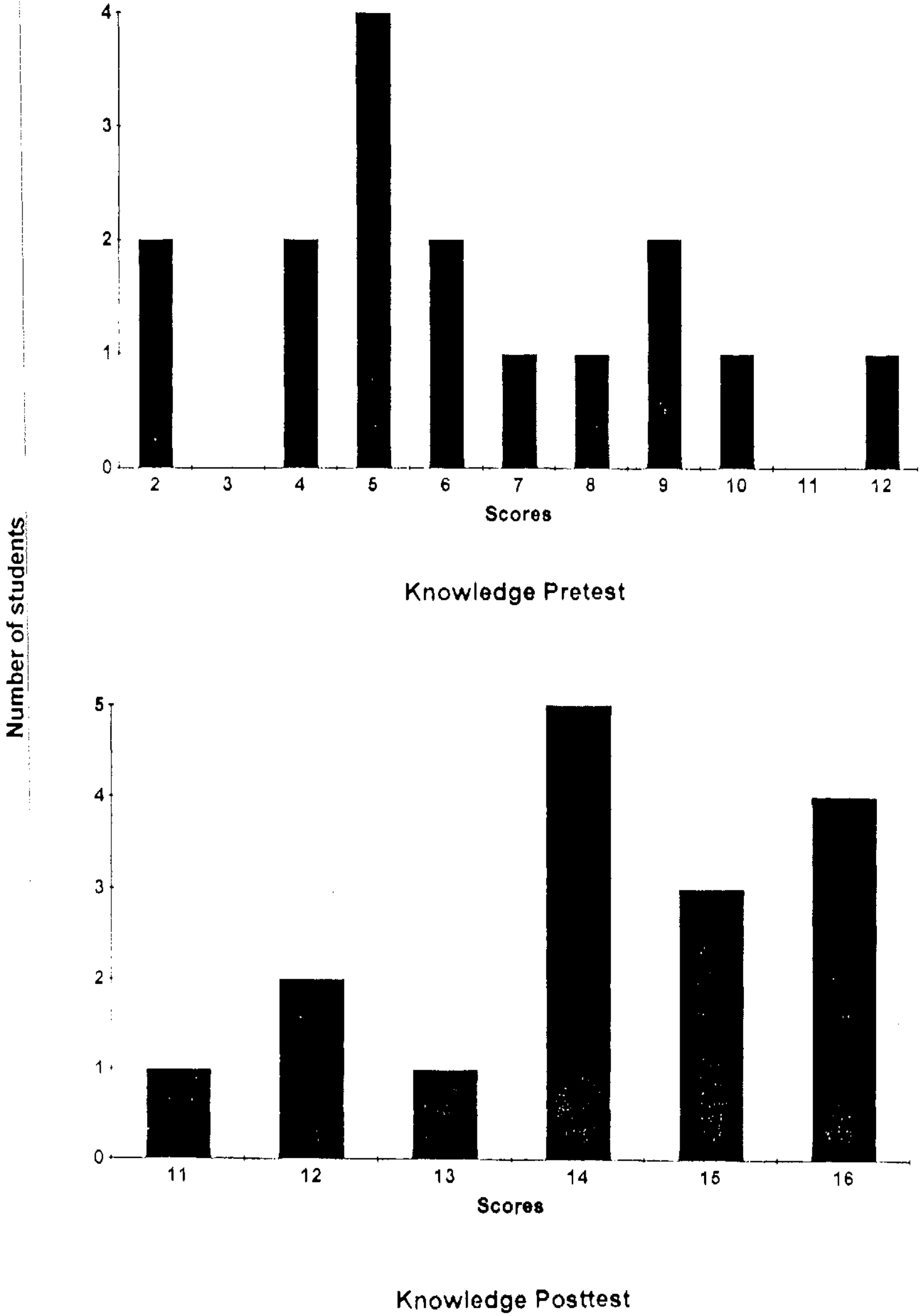


Figure 1. Frequency of scores on knowledge pretest and posttest. The maximum knowledge score was 16.

Table 2

Numbers of Missed and Correct Responses to Pretest and Posttest Items in the Environmental Knowledge Survey

Environmental Knowledge Survey	Pretest		Posttest	
	#Correct	#Missed	#Correct	#Missed
Section 1				
1. Suppose that an ecosystem in a certain area includes the following: grasses, trees, soil, rocks, grass-eating mice, air, water, and mouse-eating owls that nest in trees.				
a. Which of these factors are biotic? Which are abiotic?	8	8	14	2
b. Describe the niche of the mice, of the owls, and of the trees.	4	12	14	0
c. Draw an ecological pyramid that includes some or all of these organisms.	1	15	13	3
d. 1. At higher and higher trophic levels, what happens to the energy available?	5	11	15	1
2. What happens to the amount of biomass?	2	14	12	4
3. What happens to the numbers of organisms?	6	10	15	1

	Pretest # Correct	Pretest #Missed	Posttest #Correct	Posttest #Missed
Section 2				
1. Photosynthesis and cellular respiration are part of which cycle(s)? a. water cycle c. carbon and oxygen cycles b. nitrogen cycle d. ethanol cycle	14	2	13	3
2. What is the process by which nitrogen gas in the air is converted to usable nitrogen compounds? a. nitrogen fixation c. nitrification b. ammonification d. denitrification	7	9	10	6
3. The nitrogen cycle is carried out primarily by a. humans. c. bacteria. b. termites. d. the water cycle.	8	8	16	0
4. The 10-percent law states that only 10 percent a. a species can be hunted during a given season. b. the total stored energy is passed on at each trophic level. c. the nitrogen in the atmosphere enters the nitrogen cycle. d. the oxygen an animal breathes is absorbed into the blood.	5	11	15	1
5. The Environmental Protection Agency predicts that four-fifths of the landfills in the U.S. will be closed by the year ________ a. 1998. b. 2250. c. 2010. d. 2000.	8	8	11	5

Table 3

Numbers of Students Choosing Each Response to Pretest and Posttest Items in the Environmental Attitude Survey

Environmental Attitude Survey

Statement	Attitude scale: No extent Pre	No extent Post	Slightly Pre	Slightly Post	Moderate Pre	Moderate Post	Considerable Pre	Considerable Post	Great Pre	Great Post
1. To what extent do you feel a sense of empathy toward the natural environment?	1	0	2	1	5	10	8	4	1	1
2. To what extent do you think your school-related experiences have contributed to your becoming more sensitive to the environment?	2	1	4	2	8	3	2	7	0	3
3. To what extent do you believe that you can influence how environmental problems and issues are solved?	1	0	6	1	5	11	4	4	0	0
4. To what extent do you believe that you have shown environmental responsibility?	1	0	2	2	11	7	2	6	0	1

Statement	No extent		Slightly		Moderate		Considerable		Great	
	Attitude scale									
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
5. To what extent would you like to be environmentally active?	2	0	3	1	6	7	4	8	1	0

Table 4

Numbers of Students Choosing Activities to Help the Environment on Pretest and Posttest

Name of Project	# of Pretest selections	# of Posttest selections
Recycling	12	11
Beach Clean Up	6	8
Litter Clean Up	3	3
Water Clean Up	2	1
Carpooling	1	3
Plant trees	1	3
Composting	1	1
Energy efficient homes	1	1
Buying rainforest	2	
Using recyclables	2	
Conserving	2	
Protesting	1	
No aerosols		2
Organic fertilizers		1
Writing politicians		1

Table 5

Numbers of Students Choosing Activities to Harm the Environment on Pretest and Posttest

Activity	# of Pretest selections	# of Posttest selections
Littering	7	7
Cutting large amounts of trees	4	2
Pollution	3	4
Smoke,burning	3	2
CFC's	4	1
Nuclear plants	1	2
Landfills	1	1
Oil spills	2	1
Forest fires	1	
Exhaust		3

Table 6

Numbers of Students Choosing Community Service Projects During the Three Week Environmental Science Unit

Name of Project	Number of students
Beach Clean-Up	19
Riding Bicycle instead of driving	2
Planting a garden	2
Building a compost pile	3
Neighborhood Clean-Up	4
Zoo volunteering	1
Intercoastal Waterway Clean-Up	1
March for Parks at Guana River	2
Recycling Magazines in Neighborhood	2
Recycling paper at school	2
Distributing recycling containers	1
Total	39

Chapter Five

Conclusion

The data suggest that the environmental science curriculum used in this study had a positive impact on student knowledge since student scores improved significantly after taking the environmental science curriculum. The mean knowledge pretest score was 6.18 while the mean posttest score was 14.18, indicating that knowledge posttest scores more than doubled. The standard deviation for the knowledge pretest was 2.72 and the knowledge posttest was 1.5. The analysis of attitude items indicate that generally attitudes shifted in a positive direction from pretest to posttest.

The analysis of items for the knowledge survey in Table 2 indicate that students improved on all of the questions except number one in Section 2 on the multiple choice section, a question concerning photosynthesis and cellular respiration. This question could have two possible answers, a situation which could have confounded the results.

The analysis of items on the attitude survey in Table 3 indicate that overall, students improved on the Likert-type scale rating for all questions. The attitude scale was rated from one to five, with three being "to a moderate extent," four being "to a considerable extent" and five being to a "great extent." A score of three or better was a desired score for attitude questions.

In question one, students were asked to rate the extent to which they felt a sense of empathy for the environment. Fourteen students answered three or better on the pretest while fifteen students answered three or better on the posttest. It was interesting to find that nine students answered four or better on the pretest but only five students answered four or better on the posttest. Overall howeverit appears, students developed slightly more empathy for the environment after participating in the curriculum.

In question two, students were asked to rate the extent to which they thought their school-related experiences had contributed to their becoming more sensitive to the environment. Ten students answered three or better on the pretest while thirteen students answered three or better on the posttest. Two students answered four or better on the pretest while ten students answered four or better on the posttest, indicating quite an increase. Students appear to have developed more sensitivity for the environment after participating in the curriculum.

In question three, students were asked to rate the extent to which they thought they could influence solutions to environmental problems and issues. Nine students answered three or better on the pretest while fifteen students answered three or better on the posttest. Four students answered four or better on the pretest and four students answered four or better on the posttest, indicating no increase at this level. Overall however, students indicated more ability to influence solutions to environmental problems after participating in the curriculum and there was more improvement in student ratings on this question than the other four attitude questions.

In question four, students were asked to rate the extent to which they had shown environmental responsibility. Thirteen students answered three or better on the pretest while fourteen students answered three or better on the posttest. Two students answered four or better on the pretest while seven students answered four or better on the posttest, indicating an increase at this level. Students appeared to show more environmental responsibility after participating in the curriculum.

In question five, students were asked to rate the extent to which they would like to be environmentally active. Eleven students answered three or better on the pretest while fifteen students answered three or better on the posttest. Five students answered four or better on the pretest while eight students answered four or better on the posttest, indicating an increase at this level. Students appeared to become more environmentally active after participating in the curriculum.

Students were asked to give examples of activities that would help the environment. (See Table 4) Students gave more answers on the pretest than the posttest but students were given more time to complete the list for the pretest than the posttest. Students were allowed to work on the pretest list at home for one night while the posttest list was completed in class at school. On both pretests and posttests, students listed recycling and beach clean-up as helpful to the environment more often than other activities. More students listed beach clean-up on the posttest than the pretest which may be a result of the beach cleaning activity that many students participated in as a teacher organized event after the pretest. The inclusion of car pooling and planting trees also characterized the posttest.

Students were asked to give choices of activities that would harm the environment in Table 5. Littering, pollution and cutting too many trees were listed more often as harmful to the environment on the pretest. Littering, pollution and exhaust fumes were listed more often as harmful to the environment on the posttest which may be a result of the curriculum that was used after the pretest.

After the students completed the environmental science unit, they were asked to participate in a four hour community service project. Students participated in eleven different community service projects as seen in Table 7. More students participated in the beach clean-up than other projects, but neighborhood clean-ups and building compost piles were also popular choices. The beach clean-up was organized by the instructor and transportation was made available to the students for this project. Many students worked in groups on their projects, but at least half the students worked alone or with help from family members.

Implications

The data from this study suggest that an environmental science curriculum that includes ecological concepts, conceptual awareness, issue investigation and environmental action skills can produce positive results in students. The use of constructivist teaching, which allows student selected projects, and creates a meaningful and engaging curriculum can improve knowledge and attitudes toward environmental problems. Students seem to become more sensitive to environmental problems as their knowledge and involvement increase.

The researcher employed action research to study her own classroom. The use of empirical data helped to quantify and qualify the use of the curriculum as a tool for teaching environmental concepts. Documenting and analyzing student responses to questions can provide good information to teachers as they teach and modify the curriculum.

The integration of environmental problems into other disciplines of study is an area for further consideration and work. As the earth's resources become increasingly challenged by humankind's exploitations, it becomes increasingly important to educate the public about responsible citizenship. Environmental science should not be the only curriculum area to undertake this goal. Interdisciplinary teaching can have positive effects on improving environmental awareness.

Further research might include collecting indepth data on student attitudes. Another researchable area is the study of the use of teaching mentors for environmental projects designed by students. Private individuals, non-governmental organizations and governmental agencies who work in environmental areas are all sources of assistance for students to investigate environmental issues.

A constructivist approach toward teaching environmental science, encouraging creative ideas and promoting sound scientific reasoning can initiate positive reform for students and educators. Such efforts surely can contribute to a better environment for all citizens to inhabit.

Appendix A

UNESCO(1977)Conference Environmental Education Principles (Disinger, 1993)

Environmental education should :

consider the environment in its totality - natural and built, technological and social(economic, political, cultural - historical, moral, aesthetic);

be a continuous lifelong process, beginning at the pre-school level and continuing through all formal and non-formal stages;

be interdisciplinary in its approach, drawing on the specific content of each discipline in making possible a holistic and balanced perspective;

examine major environmental issues from local, national, regional and international points of view so that students receive insights into environmental conditions in other geographical areas;

focus on current and potential environmental situations, while taking into account the historical perspective;

promote the value and necessity of local, national and international cooperation in the prevention and solution of environmental problems;

explicitly consider environmental aspects in plans for development and growth;

enable learners to have a role in planning their learning experiences and provide an opportunity for making decisions and accepting their consequences;

relate environmental sensitivity, knowledge, problem-solving skills and values clarification to every age, but with special emphasis on environmental sensitivity to the learner's own community in early years;

help learners discover the symptoms and real causes of environmental problems;

emphasize the complexity of environmental problems and thus the need to develop critical thinking and problem-solving skills; and

utilize diverse learning environments and a broad array of educational approaches to teaching/learning about and from the environment with due stress on practical activities and first-hand experience.

Appendix B

Environmental Education References

Project Learning Tree, published by the American Forest Council (Boulder,CO:WREEC, 1988). This is a supplementary activity guide with information and activities related to forests and forest systems.

Project WILD, published by Western Regional Environmental Education Council(Boulder, CO: WREEC, 1992). This text includes activities about wildlife, ecosystems, habitats, and other ecological concepts.

Global Change Education Resource Guide, published by the National Oceanic and Atmospheric Administration (Silver Spring, MD: U.S.Department of Defense, 1994). This is a collection of materials gathered from Federal agencies, non-profit organizations, environmental and educational associations, and schools and international organizations on topics including natural climate variability, greenhouse effect, sea-level rise, ozone depletion and decision-making within scientific uncertainty. Included is a bibliography of recent environmental education materials.

<u>4 R's Project, A Solid Waste Management Curriculum for Florida Schools - 6th-8th grade</u>, Edited and written by David E. LaHart, published by Florida Department of Education, 1989. This is a supplementary resource on solid waste recycling. It is based on the 1988 Solid Waste Management Act (SWMA) and designed to encourage actions to solve Florida's solid waste problems. This resource includes activities that address four levels of conceptual awareness in environmental education: knowledge, attitudes and values, decision making, actions and behaviors.

<u>4 R's Project, A Solid Waste Management Curriculum for Florida Schools - 9th-12th grade</u>, Edited and written by Linda Cronin Jones, published by Florida Department of Education, 1989. This is a supplementary resource on solid waste recycling for high school students.

Appendix C

Environmental Knowledge Survey Key

The following is a questionnaire about the environment. Read each question or statement and respond in the space provided.
Please attempt to answer each question even though you may not know for sure. This is not a graded quiz or test.

I.

1. Suppose that an ecosystem in a certain area includes the following: grasses, trees, soil, rocks, grass-eating mice, air, water, and mouse-eating owls that nest in trees.

a. Which of these factors are biotic? Which are abiotic?

Biotic - grasses, trees, mice, owl

Abiotic - soil, rocks, air, water

b. Describe the niche of the mice, of the owls, and of the trees.

Mice - eat grasses, provide food for owls
Owls - eat mice, fertilize trees
Trees - photosynthesize and provide habitats

c. Draw an ecological pyramid that includes some or all of these organisms.

OWLS
MICE
GRASSES & TREES

d. At higher and higher trophic levels, what happens to the energy available? What happens to the amount of biomass? What happens to the numbers of organisms?

Energy, biomass and the number of organisms decrease as you go up the trophic levels.

II.

a or c 1. Photosynthesis and cellular respiration are part of which cycle(s)?

a. water cycle c. carbon and oxygen cycles

b. nitrogen cycle d. ethanol cycle

a 2. What is the process by which nitrogen gas in the air is converted to usable nitrogen compounds?

a.nitrogen fixation c. nitrification

b. ammonification d. denitrification

c 3. The nitrogen cycle is carried out primarily by

a. humans. c. bacteria.

b. termites. d. the water cycle.

b 4. The 10-percent law states that only 10 percent of

a. a species can be hunted during a given season.

b. the total stored energy is passed on at each trophic level.

c. the nitrogen in the atmosphere enters the nitrogen cycle.

d. the oxygen an animal breathes is absorbed into the blood.

c 5. The Environmental Protection Agency predicts that four-fifths of the landfills in the U.S. will be closed by the year

a. 1998. c. 2010.

b. 2250. d. 2000.

Grading Key:

Section I.a.= 2 points
b.= 3 points
c.= 3 points
d.= 3 points

Section II. = 5 points

Total = 16 points

The following questions are related to your personal views on the environment. Respond to each question by circling the number that best reflects your opinion. The scale values should be interpreted as follows:

1 = to no extent
2 = to a slight extent
3 = to a moderate extent
4 = to a considerable extent
5 = to a great extent

1. To what extent do you feel a sense of empathy toward the natural environment? 1 2 3 4 5

2. To what extent do you think your school-related experiences have contributed to your becoming more sensitive to the environment? 1 2 3 4 5

3. To what extent do you believe that you can influence how environmental problems and issues are solved? 1 2 3 4 5

4. To what extent do you believe that you have shown environmental responsiblity? 1 2 3 4 5

5. To what extent would you like to be environmentally active? 1 2 3 4 5

Please give examples of activities that you think would help the environment.

Please give examples of activities that you think would hurt the environment.

Appendix D

Content Outline for Environmental Science Curriculum

I. Biosphere - living and non-living portions of the Earth that sustain life

   A. Ecology - the study of organisms and their interactions with the environment

   B. Ecosystem - a community of biotic organisms and abiotic factors within a certain area

      1. Biotic factor - a living organism in an environment

      2. Abiotic factor - a non-living part of an environment
         a. sunlight, water, air, soil, minerals

   C. Niche - the way of life of an organism in an environment, an organisms job, interactions with abiotic and biotic factors in an environment

   D. Physical environment - the location, composition (abiotic factors) and attributes of a specific area

      1. Climate - the typical weather patterns of an area over time - temperature and precipitation

         a. Latitude - the distance north or south of the equator
            1. Climate zones - areas of temperature and precipitation determined by latitude at 30 degree increments (tropical, temperate, arctic)
            * Lab activity - Climate zones

         b. Altitude - the distance above sea level
            1. Climate zones - areas of temperature and precipitation determined by altitude (2 degree drop / 300 meters increase)

      2. Soil and minerals - organic and inorganic substances in a specific environment

a. Rock cycle - a series of changes in the composition and structure of rocks - igneous, metamorphic, sedimentary through heat, compression and erosion

* Lab activity - Soil Type and Water Activity

3. Light - the primary energy source for photosynthesis and food chains in an environment - related to location

II. Biomes - a major type of ecosystem having its own temperature ranges, rainfall amounts and types of organisms determined by location

A. Tundra

B. Taiga

C. Rainforest

D. Grassland

E. Chaparral

F. Desert

G. Temperate forest

* Lab Activity - Biomes

H. Aquatic

A. Marine - all the oceans and their shorelines - 70% of Earth

1. Marine zones - areas of the ocean determined by light, temperature, water pressure, and salinity

a. Intertidal - coastal, alternately covered and exposed by water, extreme variation in temperature and salinity

b. Neritic - above the continental shelf, rich in nutrients, photic, abundant phytoplankton

c. Oceanic - beyond continental shelf

1. Photic - 200 meters deep, light penetration, autotrophic and heterotrophic

2. Aphotic - below 200 meters, no light penetration, heterotrophic, bioluminescent

3. Benthic - ocean floor, no plants, many scavengers, invertebrates, and flat fish. Estuary - a shallow area where fresh and salt water meet and mix (brackish) - "the tide" 10% of marine biome, 90% marine life, marine nurseries, nesting areas

B. Freshwater - rivers, lakes and ponds, more temperature and seasonal change than marine biomes, photic, aphotic and benthic zones

1. Moving - rivers, streams, require special adaptations for currents

2. Standing - ponds and lakes, producers, consumers and decomposers, eutrophication - water with low oxygen content, usually caused by phosphorus detergents or high nitrogen fertilizers

* Lab activity - Nutrients and algae growth

3. Wetland - an area where fresh water and land meet, marsh, swamp,bog, large varieties of plant and animal life, good habitats for many organisms, housing developments encroaching

III. Energy Flow in Ecosystems

A. Thermodynamics - the study of heat and work and the conversion of energy from one form to another

1. First law - energy cannot be created or destroyed

2. Second law - energy can be changed from one form to another but some usable energy is lost as heat

B. Ecosystems require a constant energy input, from the sun

C. Trophic levels - each step in the transfer of energy and matter in a community - "food" or "to feed"

1. Producers - the first trophic level, autotrophs, chemosynthesizers - convert inorganic to organic (plants, sulfur bacteria)

2. Consumers - trophic levels above producers, heterotrophs

a. Primary - feeds directly on producers, herbivore (insect, rodent, fish)

b. Secondary - feeds on herbivores, carnivore (frog, snake, bird)

c. Tertiary - feeds on carnivores, predator (owl, fox, lion)

d. Scavenger - feeds on dead or decomposing organisms (buzzard, crow)

3. Omnivore - primary, secondary and tertiary, eats producers and consumers (bears, dogs, humans)

4. Decomposers - break down dead organisms and wastes into simple compounds (bacteria, fungi)

D. Trophic level interactions

1. Food chain - the flow of energy from one trophic level to another

2. Food web - all the interconnected food chains in an ecosystem

* Worksheet and lab activity - Food webs and trophic levels

3. Biomass - the total mass of organic matter at each trophic level

4. Food pyramid - a pyramid shaped diagram that illustrates the amount of biomass in each trophic level, biomass decreases as you move up the trophic levels

a. 10% law - the amount of energy available at each trophic level in a food pyramid is equal to 10% of that energy in the trophic level directly below, 90% total energy loss

* Worksheet - Calculating energy transfer in an ecosystem

E. Chemical cycling -

1. Water - movement of water between Earth's surface and the atmosphere (evaporation, condensation and precipitation) used in photosynthesis,produced in respiration and waste products (urination, perspiration)

2. Carbon and oxygen - movement of carbon and oxygen through an ecosystem, used in photosynthesis and respiration, produced during decomposition of organisms and limestone, released from fossil fuels (carbon dioxide, organic compounds) related to greenhouse effect (carbon dioxide absorbs earth heat)

3. Nitrogen - the pathway by which nitrogen moves through an ecosystem, biogeochemical cycle

a. Nitrogen fixation - nitrogen gas converted to usable nitrogen compounds, nitrogen fixing bacteria in soil, legumes (alfalfa, peanuts, clover, peas) convert nitrogen gas (N_2) to ammonium ions (NH_4^+), stored in roots or soil lightning converts nitrogen and oxygen to nitrogen oxides which form nitric acid fertilizers containing nitrogen

b. Nitrification - ammonium ions converted into nitrates, bacteria convert ammonium (NH_4^+) to nitrite (NO_2^-) and to nitrate (NO_3^-). Nitrates absorbed by plant roots and converted into amino acids or other nitrogen containing compounds

c. Ammonification - the decomposition of nitrogen compounds in the remains of organisms into ammonia by nitrifying bacteria

d. Denitrification - the conversion of ammonia, nitrite or nitrate into free nitrogen gas

IV. Environmental Concerns

A. Human impacts and adaptations

1. Population growth - greatest in last 300 years, about 6 billion now and increasing about 90 million per year

a. Causes - improved technology - medical, agricultural and industrial

b. Effects - Depletion and pollution of natural resources and organisms, lower quality of life, political instability, drastic social change

2. Sustainable development - the development of the Earth while maintaining the resources needed for future life

a. Gaia hypothesis

3. Environmental awareness

a. Biological magnification - the build-up of pollutants in organisms at higher trophic levels in a food chain (DDT)

b. Carrying capacity - the number of organisms that can be supported by an ecosystem

c. Conservation

B. Air

1. Pollution sources

a. Greenhouse gases
55% - Carbon dioxide
15% - Methane
24% - CFC's
6% - Ozone (from carbon monoxide, Nitrogen monoxide, methane)
- Water vapor

b. Greenhouse effect and global warming

C. Water

1. Pollution sources
   a. Agricultural runoff
   b. Erosion
   c. Chemical dumping
   d. Heat

D. Land

1. Degradation
   a. Erosion
   b. Desertification
   c. Deforestation

2. Waste management
   a. Recycling

E. Energy

1. Production
   a. Cogeneration
   b. Fossil fuels
   c. Hydroelectric
   d. Nuclear
   e. Wind
   f. Solar

2. Future

F. Biological Diversity

1. Genetic relationship
   a. Adaptations

2. Environmental relationship
   a. Food chains, food webs

3. Consequences

* Lab activities - Issue analysis

Appendix E

Environmental Action Project

Purpose - As part of the unit on ecology, Biology students will participate in an environmental action project. This project will require a minimum of four hours of community service related to an environmental issue of your choice. You will also prepare a written report which will contain the following information.

1. Selection of topic - This is a definition or discussion of the environmental issue you have chosen.

2. Background information - This section should include any information related to the topic and a discussion of why it is an environmental issue.

3. Method of participation - As a detailed account of your plan of action, you should discuss why you chose this plan in relationship to the environmental issue.

4. Results - Observations that you make related to the activity could include both environmental effects and your personal responses to the activity. This section should be in the form of a journal, with daily entries noted. A community service sheet, completed and verified by an outside observer, should be included.

5. Conclusion - This is a discussion of the effects of this project on the environment and plans you may have for future work.

Project Due Date - May 5, 1995

Environmental Activities Ideas

1. Beach Clean-Up
2. State Park volunteer
3. Paper Recycling
4. Neighborhood Beautification Project
5. Local Environmental Action Group Participation (BEAKS, Sierra Club, Riverwatch, Guana River Walk)
6. Zoo volunteer
7. Monitoring the water quality of a local river, stream, or lake
8. Measuring the amount of particulates in the air to determine the air quality
9. Conducting acidity tests on rainfall
10. Contacting city or county environmental agencies to volunteer
11. Performing a wildlife population study
12. Planting trees
13. Organizing recycling in local apartment complexes
14. Improving campus environmental awareness or practices
15. Writing letters about local environmental issues (land use management, greenspace planning, Rodman reservoir, manatee protection)

Appendix F

Lab Activity - Climate Zones

Purpose - To recognize the location, temperature and precipitation of the three climate zones; tropical, temperate and arctic.

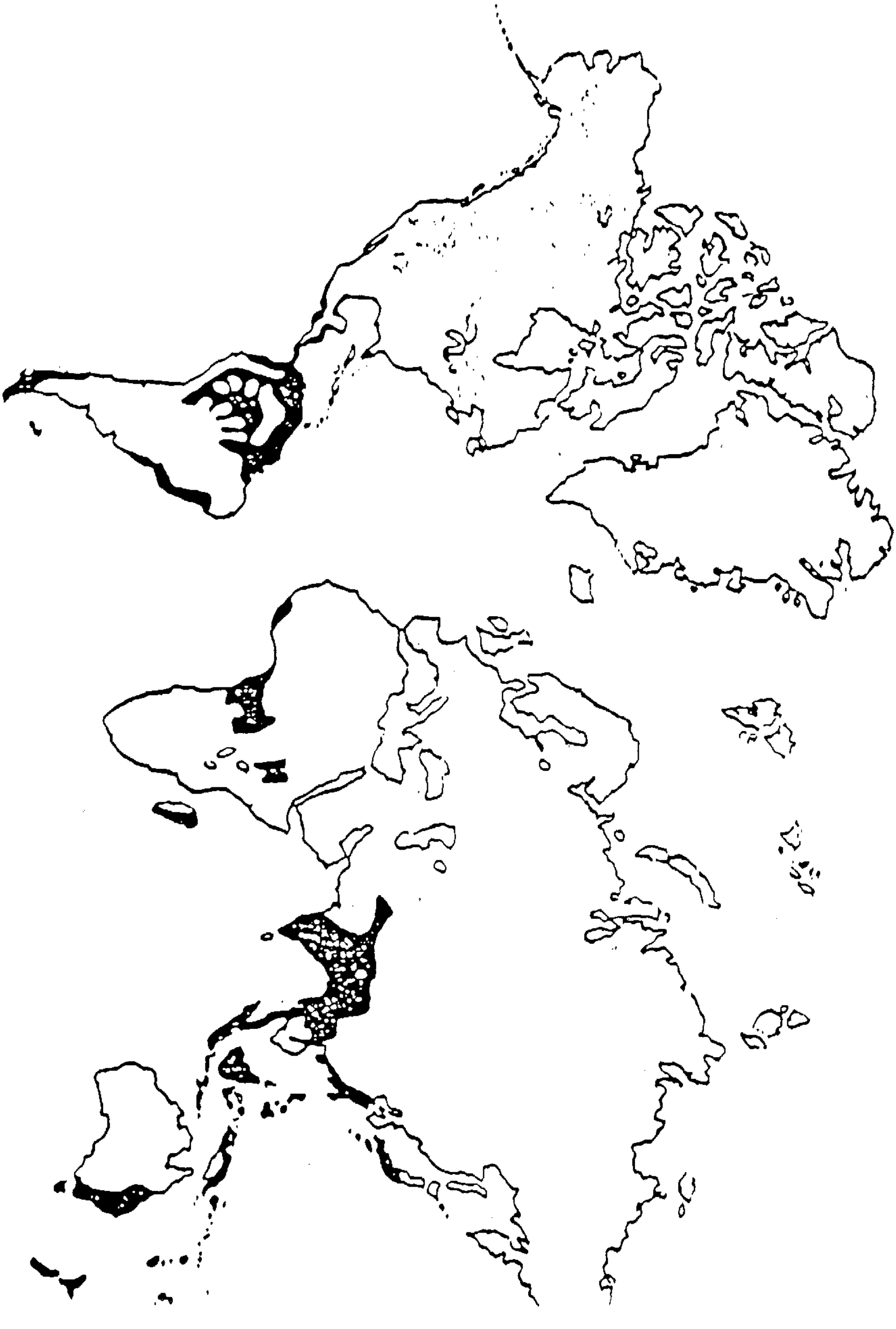
Procedure - Students use texts or reference books to shade the world map with the three climate zones and complete the climate zone chart with the appropriate information.

Climate Zones

	Tropical	Temperate	Arctic
Temperature	18 C. constant	10 - 18 C. varies	> 10 C.
Precipitation	250 - 300 cm./yr. rain	60 cm./yr. rain, snow	40 - 50 cm./yr. snow
Latitude	0 - 30	30 - 60	> 60

Climate Zones

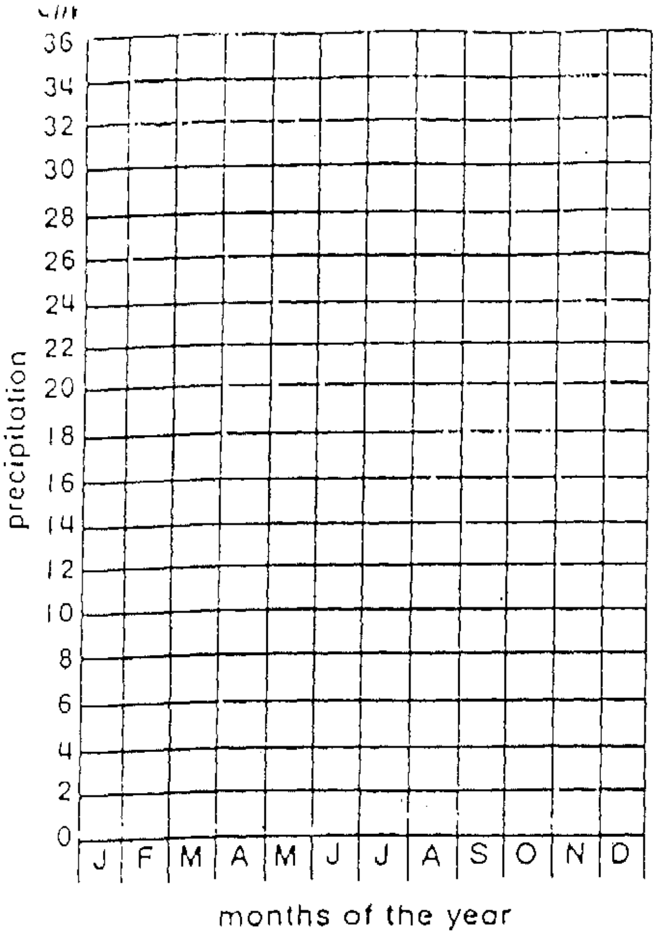
	Tropical	Temperate	Arctic
Temperature			
Precipitation			
Latitude			

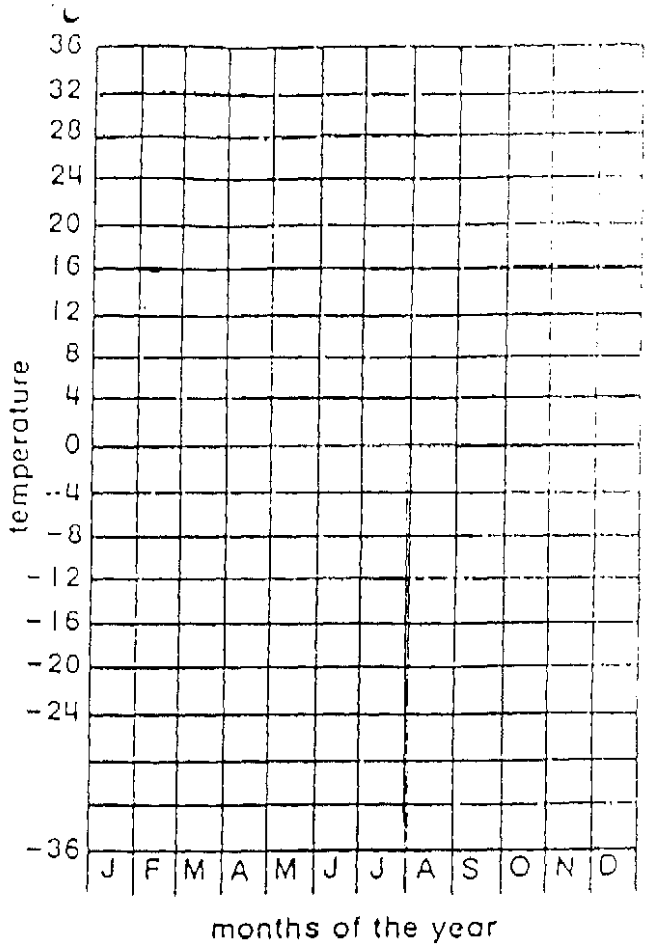


Lab Activity - Biomes

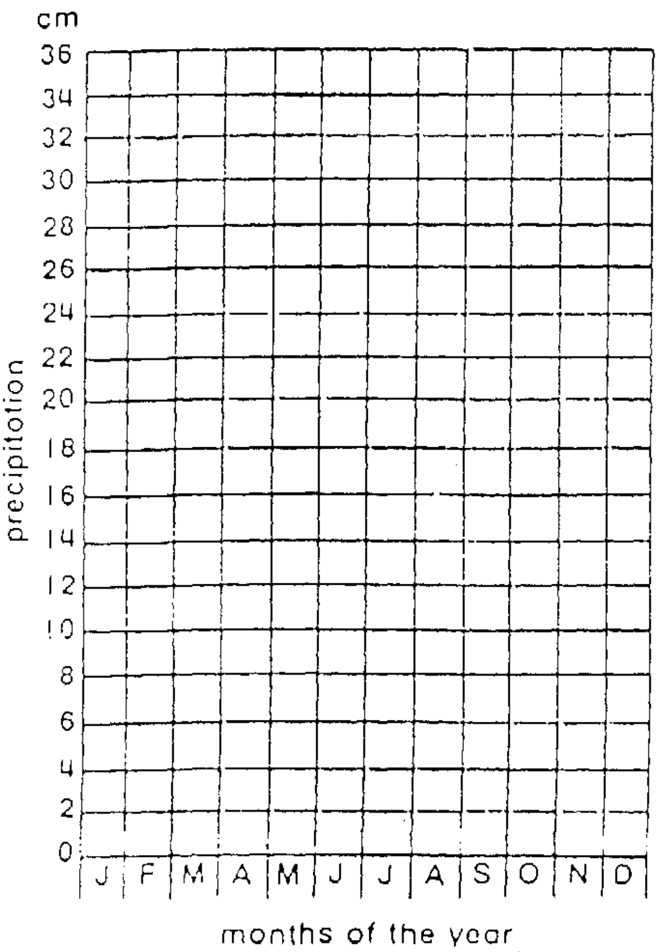
Purpose - To locate the major world biomes and record the precipitation in those biomes.

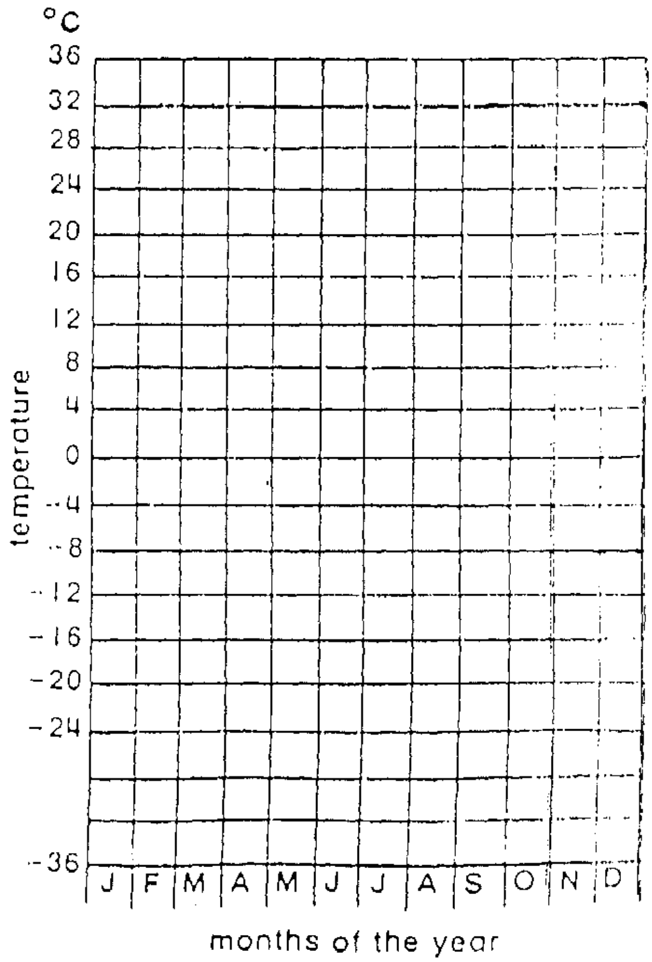
Procedure - Students will use texts or reference books to shade in the major biomes on the world map and record the monthly precipitation and temperature for each biome on the graphs.





Biome Name________________________





Biome Name________________________

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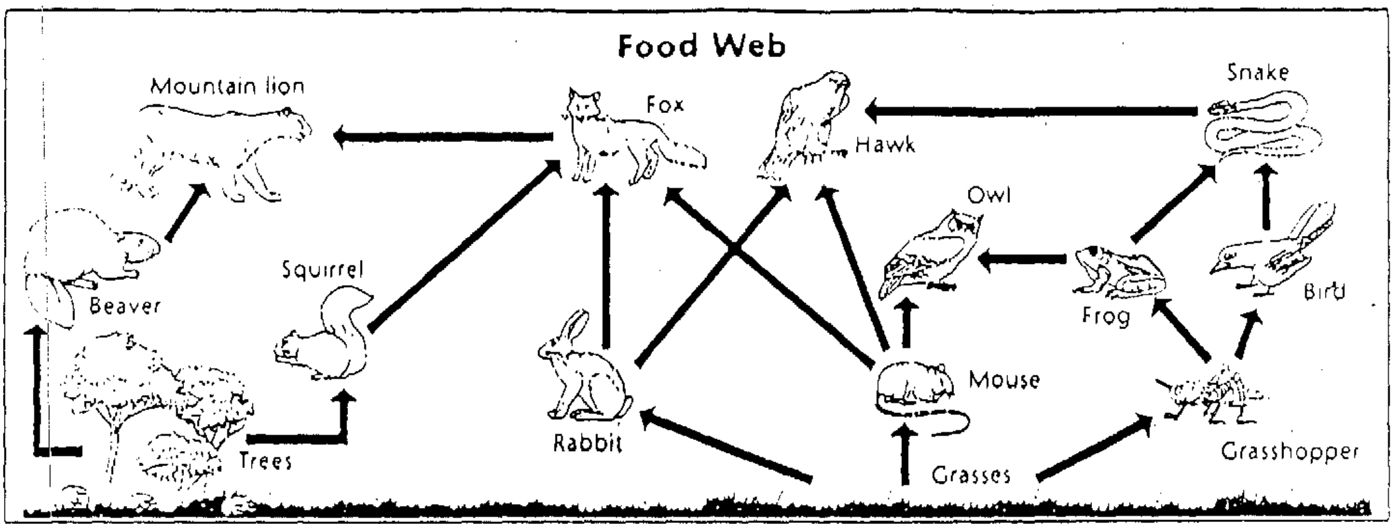
Name ______________________ Class ______________________ Date ______________________

Critical Thinking Diagram Worksheet 46-1



PART A *Use the information shown in the diagram to complete the following.*

1. Identify a food chain that consists of only a producer, a primary consumer, and a secondary consumer.

____

2. Identify a food chain that consists of a producer, a primary consumer, a secondary consumer, and a tertiary consumer.

____

3. Identify three herbivores shown in the diagram. ______________________

4. Identify three carnivores shown in the diagram. ______________________

5. Add decomposers to the food web by writing the term Decomposers in the correct place and adding arrows as appropriate.

6. What do the arrows indicate about the flow of energy through the community. ______________________

____

PART B *Complete the table by classifying each organism shown in the food web in its correct trophic level. Some organisms may be listed in more than one trophic level.*

TABLE 1 CLASSIFYING ORGANISMS IN TROPHIC LEVELS

PRODUCERS	PRIMARY CONSUMERS	SECONDARY CONSUMERS	TERTIARY CONSUMERS

Name ______________________ Class ______________________ Date ______________________

Process Skills Worksheet 46-1

Calculating Energy Transfer in an Ecosystem

Organisms get the energy they need from food. Because organisms at each trophic level use some energy to carry on their life processes and give off some energy as heat, the transfer of energy from one trophic level to the next is not 100 percent efficient. In fact, as much as 90 percent of the energy taken in by an organism may be used by the organism or lost as heat. Thus, only about 10 percent of the energy taken in by the organism is available to organisms at the next trophic level. Ecologists refer to this loss of available energy at each successive trophic level in the food chain as the ten-percent law.

Use the concept of the ten-percent law to calculate the amount of energy available in each situation described. Show your work at the bottom of this page.

1. A total of 15,000 Calories of energy exists at the producer level in a community. How much energy will be available for the organisms at each of the following levels?

   a. primary consumers ______________________

   b. secondary consumers ______________________

   c. tertiary consumers ______________________

2. If the primary consumers in a community have an energy supply of 5000 Calories, how much energy will be available for the tertiary consumers?

____

3. If the tertiary consumers in a given community have 500 Calories of energy available to them, how much energy was available at the secondary consumer level?

____

4. Use the ten-percent law to explain why an ecosystem can support fewer tertiary consumers than primary consumers.

____

____

____

CALCULATIONS

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Should Endangered Plants Be Reintroduced?

The extinction of plant and animal species is nothing new. Since life first appeared on earth 3.5 billion years ago, as many as 500 million species of plants, animals, and microorganisms have lived on this planet. Scientists estimate that between 5 and 6 million species of organisms exist on Earth today. Thus, since the beginning of life on Earth, more than 490 million species, or 99 percent, have become extinct.

Most of these extinctions had a natural cause. But today, a new force is causing extinctions on a massive scale. This force is human beings.

Endangered Plants When immigrants arrived in the Americas from Europe, they brought European plants with them. Many of the plants that the immigrants brought were crops like onions and turnips, but they brought other plants as well. These plants included flowers and even weeds that were accidentally carried in the ships of the immigrants. Some of these plants thrived, and began to spread.

As time went on, people brought other plants to the Americas. Ornamental shrubs, flowers, and even trees were brought from all over the world. Some of these plants were able to grow well in American soil— better, in fact, than the plants that were already living there.

Introduced plants have become a chronic problem in the United States. Weeds like dandelions and ragweed seem to grow everywhere, but they are not native to the Americas. Both weeds were introduced by European settlers. The dandelion has been especially successful, and has spread from the east coast to Mexico, California and Canada in only a few hundred years. The dandelion has grown at the expense of native plants and wildflowers. Many Colorado wildflowers lose large parts of their range every year to the encroaching dandelion.

Even trees can encroach on a native ecosystem. Eucalyptus trees are common in California, but there were no eucalyptus in California until a few hundred years ago. The trees were introduced from Australia, and have spread quickly. European grasses have also encroached successfully in California. As a result, the California ecosystem has changed radically, and many native California plants have disappeared or live only in small, relic populations.

A final problem for native plant species is habitat destruction. Constant development has destroyed many of the habitats of native plants and has further reduced their range. Many native plants are caught between encroaching, non-native plants on one side and a developer's bulldozer on the other. It is not surprising that many of these plants are endangered species.

Reintroducing Native Plants Scientists and conservationists are attempting to save many of the plant species that have been displaced by human activity. Seeds of endangered plants are stored in seed banks, and some are introduced back into the wild. Reintroducing endangered plants seems like a good idea, but reintroducing plants brings up several problems.

The first problem is that reintroductions are usually not successful. A survey of 45 plant relocation projects in California showed that only four of the projects were total successes. Fifteen of the projects were only partially successful, and ten were complete failures. A similar study performed in England showed that only 22 percent of 144 plant relocations were successful. The rest were failures or probable failures.

If an endangered plant is successfully reintroduced to an area, it may cause other problems. The plant is in its natural environment and may encroach on the plants already living there. These plants in turn may become endangered, making the problem worse instead of better. The reintroduced plant may also disrupt the natural ecosystem of the area.

Plant species continue to be displaced by encroaching non-native plants, and by habitat destruction. People may attempt to reintroduce these plants into other areas, but they are not addressing the real problem. The real problem is that the natural habitats of these plants have been destroyed. Attempts to reintroduce them in other areas are often not successful, and if they are successful they may cause other problems. The best way to protect an endangered plant is to not destroy its environment in the first place.

ssues and Decisions 25-1

EVIEW *In the space provided, answer the questions following.*

1. Name two factors that threaten native plant species.

2. What are some problems that plant reintroduction can cause?

ONSIDER THIS *In the space provided, answer the questions following.*

1. Should plant species be reintroduced? Explain your reasoning.

2. Do you think that it is important to save every species of plant from extinction? Give reasons ıpporting your answer.

Issues and Decisions 29-1

What Are the Risks Involved in Using Pesticides?

Pesticides are chemicals that kill destructive or troublesome organisms, or pests. Many pests destroy food crops. These pests include weeds, insects, bacteria, fungi, birds, and rodents. By using pesticides farmers can reduce the damage done to their crops, which results in higher yields and lower food costs to consumers. More than 50,000 kinds of pesticides are sold worldwide. Unfortunately, some of these pesticides have been found to be harmful to people, animals, and other living things.

Kinds of Pesticides Two kinds of pesticides are commonly used: contact and systemic. When a *contact pesticide* is sprayed on plants, it kills by direct contact. These pesticides can kill weeds, insects, and other small animals on contact. *Systemic pesticides* contain chemicals that enter the tissues of a plant being protected, usually through the roots. The chemicals protect the plant from infection by killing the bacteria already inside it. They also control organisms, such as scale and white fly, which attack the plant's exterior.

Systemic pesticides also enter any organism that eats the plant. Birds and other animals may end up accumulating these chemicals in their bodies. These chemicals can injure and kill the animals that ingest them. The chemicals are also passed on to predators higher in the food chain, including humans.

Living Things and Pesticides Some pesticides can cause cancer in humans. The Environmental Protection Agency (EPA) estimates that one fourth of commonly used pesticides may contribute to the development of cancer. EPA scientists and other researchers are constantly studying pesticides to determine the dangers they represent, but these tests are expensive and time consuming. At this time, only about one third of the pesticides currently sold in this country have been adequately tested. Pesticides produced before 1978 are not required to be tested, although they are still on the market.

The pesticide DDT was created to kill insects on farm crops as well as those insects that spread diseases to humans. DDT is a strong chemical that stays in plants and soil for long periods of time. Livestock that feed on crops treated with DDT accumulate the pesticide in their bodies. Once in the soil, DDT can be washed into rivers and other waterways by rainfall. Fish become poisoned and spread the poison to animals and people who eat them. DDT attacks the nervous system and causes irritation, convulsions, coma, and death. Because of this danger, it has been banned in the United States since 1972. DDT is still exported to other countries, however, where it is used to kill insects that spread such deadly diseases as typhus and malaria.

Endrin is a pesticide which is fifteen times more poisonous to mammals than DDT. It can produce cancers and birth defects in humans. Although it has been banned for some uses in the United States since 1979, it is still used on sugarcane, rice, grain, and cotton in the South and Midwest and on fruit orchards in the East.

Nearly everyone has some contact with pesticides in food, in gardens, or in contact with soil or water. A few people, such as farmers, forestry workers, and those who make pesticides, are exposed to large amounts of pesticides on a daily basis. These people are at high risk for the health problems that come from pesticides. To protect themselves, these workers should wear special clothing and breathing masks.

REVIEW *In the space provided, answer the questions following.*

1. What problems can pesticides cause in humans and other animals that they were not intended to harm?

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Issues and Decisions

2. Which government agency tests pesticides and regulates the sale of pesticides in the United States? Why have so few pesticides been adequately tested?

CONSIDER THIS *In the space provided, answer the questions following.*

1. Some farmers use DDT illegally because it is so effective in killing pests. What do you think should be done to stop the illegal use of pesticides? Explain your answer in an open letter to farmers that would be suitable for printing in a newspaper.

2. Some scientists think that it is acceptable for developing nations to use pesticides that have been banned in the U.S., because those nations must raise more crops to save their people from hunger and even starvation. Do you agree with this? Why or why not?

Should Humans Deliberately Interfere in the Balance of Predator-Prey Relationships?

Wolves, which once roamed over most of the United States, have been hunted and trapped nearly out of existence. People feared wolves and sought to protect their livestock. Now wolves are endangered except in northern Minnesota, on Isle Royale in northern Wisconsin, and in Alaska. In Alaska, wolves are so plentiful that state agents used to shoot wolves from airplanes in order to increase the numbers of moose and caribou. Big game hunters like to hunt moose and caribou. The airplane hunts stopped when tourists threatened to boycott the state.

In other areas of the United States, wildlife managers advocate using wolves to control the numbers of deer, elk and other hoofed mammals. In Yellowstone National Park, wolves were wiped out long ago. Now there are so many elk that many of the elk are dying of starvation. Allowing the return of natural predators, some argue, will help restore the balance of nature.

Should the predators be kept in check so hunters can control flocks of deer, elk, and other game animals? Or should wildlife managers use wolves and other predators to control animal populations?

Wolves In the mid-1870s, wolves were plentiful and so was their food supply. In the west, wolves hunted and killed bison. During the 1880s bison were hunted by humans until they were nearly extinct. At the same time, ranchers began to arrive so that cattle and sheep replaced the bison. Since the wolves' natural food supply had largely disappeared, wolves took advantage of the new source of food: livestock. Cattle ranchers, to protect their herds, began to hunt the wolves. In Montana alone, more than 80,000 wolves were killed between 1883 and 1918. Wolves were nearly wiped out.

In 1973, wolves gained protection under the Endangered Species Act and could no longer be hunted. In Minnesota, where wolves were thriving and occasionally killing livestock, people were outraged. Ranchers could not kill the wolves attacking their herds. Ranchers were forced to allow U.S. Fish and Wildlife Service officials to live-trap and move wolves. Finally in 1978, wolves were reclassified as threatened in Minnesota so that problem wolves could be trapped and killed.

Biologists say that wolves do not attack domestic animals usually, and prefer wild game. However once wolves start killing livestock, they do not stop. Understandably, ranchers want to hunt wolves to keep them from destroying herds.

Hunters think that wolves will interfere with the sport hunting of deer, elk, moose, and caribou. Some biologists say, however, that wolves actually encourage healthy populations of these animals and improve big game hunting. Wolves usually take the weaker animals that would have died from starvation anyway. Nevertheless, when the numbers of wolves increase, there can be a greater threat to game animals and greater competition with hunters.

Deer In the northeastern United States, the whitetail deer population is exploding, and there are no wolves to control them. Deer have been plentiful and widespread throughout North America for the last 2.5 million years. When Europeans started immigrating to North America, the number of deer was at its peak—between 24 and 36 million deer. From 1850 to 1900, deer were hunted, forests were cleared, and livestock ate the vegetation that the deer would have eaten. The number of deer fell to about 500,000.

Then hunting laws changed, forests began to grow back, and the numbers of deer surged. Today wildlife biologists estimate that there may be as many as 25 million deer. The comeback of the deer was more successful than anyone imagined. Surprisingly, the deer are doing best in the suburbs and other areas developed by humans. Biologists attribute the deer's success to the relatively mild winters between 1978 and the early 1990s, and to modern agriculture. Fertilizers have increased crop yields, so that deer have had more than enough to eat. Well-fed deer reproduce more often. Also, suburban development has divided the land into patches of forest, fields, and gardens. Deer can wander easily into people's yards to nibble on delicious shrubs, flowers, and young trees. Most of the deer's predators—wolves, bobcats, and bears—have been eliminated. Hunting is prohibited in suburbs and other densely populated areas. Consequently deer are quite protected.

In fact, the deer have become a public nuisance. Not only do deer damage gardens by eating the plants, but they have even been known to charge through plate glass windows and trot through people's houses. Automobile collisions with deer have become frequent. Moreover, deer have ticks that carry Lyme disease.

Should There Be a Global Effort to Limit Population Growth?

In 1990, there were 5.3 billion people in the world. Analysts in a United Nations study predicted there could be 694 billion people on our planet by the year 2150. That would be 12,100 people for every square mile of land, a population density that now exists only in the most crowded cities. With this population density where would there be farmland to sustain this huge population? Clearly there would be no way that such a human population could be fed. Whether or not you accept the date of 2150 for such a catastrophe, the human population could outstrip its capacity to support itself at some point. The question, therefore, is not whether to limit human population, but when to begin and by what methods.

The Present and the Future At present, even with advanced technology for farming and raising of livestock, a billion people live at a level close to starvation. Most starving people are in the developing nations of the world, and most of the victims of starvation are children under the age of five. Some economists say that current food shortages are due to the problems of food distribution between rich and poor nations. The industrialized nations of Europe, America, and the Pacific rim of Asia use a disproportionate share of the world's resources, including food. Many poorer nations export their food crops to pay their debts to the richer nations. As a result of using their crops to pay debts, some nations lack enough free farmland to grow crops for their own people. Also, some nations are too poor to import crops or the technology needed to improve this situation. Political problems such as civil wars also raise the level of starvation.

Demographers, scientists who study the human population, come up with different timetables for population catastrophe. Their estimates of how many people the world can feed are based on many factors such as population growth rates, numbers of various ages, and the services people need to exist at a certain level of health and civilization. Other factors include where people will live (cities or rural areas), migration patterns, and effects on the environment of population levels. According to the World Hunger Program at Brown University, earth's resources could now feed 5.5 billion people. These estimates are based on the assumptions of present levels of food production and equal distribution of food to all people and no eating of dairy and meat products.

If world population reaches 11 billion in 2050 some people think that great damage is likely to have occurred to the environment in the attempt to feed, house, and care for these people. According to some demographers, millions of people in depleted areas may try to move to countries that have preserved their environments. At worst, the people may be living in a world that is mostly desert, with small patches of tropical forests, mountains worn down by erosion, dead coral reefs, and oceans empty of life. In such a world, there would also be weather extremes because sparse vegetation would not protect against winds and would not release enough oxygen and use enough carbon dioxide.

To prevent an environmental disaster, some scientists are urging nations to cut the rate of human population growth in half and keep the population from rising above 8 billion by 2050. The scientists warn that there are already no new habitable areas for people to settle. Natural resources for energy and other uses are limited, and most dumping space for garbage is already filled. With more people to support, people are destroying the ecosystems of plants and animals we need. By 2050, many more living things could be extinct.

Could Technology Save Us? Some scientists argue that people could someday invent technology that would provide enough food for a much larger world population. In the twentieth century, crop yields have been greatly increased by the use of fertilizers and pesticides. Improved breeds of plants and animals provide more and better food, and farmers have better machines and farming methods.

Others argue that no one can be sure that such a technology will exist or be in place in time to save billions from mass starvation. Even if the technology exists someday, it may not be available to many because of human rivalries and war. Also, they argue, land for farming will be limited by construction of new homes, factories, and schools and other uses. Farming is limited also by availability of fresh water and energy and by problems of pollution and erosion.

Controlling Population Growth Changing population growth patterns may be difficult. Rural people in developing nations have large families so that there will be young people to work on farms and children to care for aging parents. Education

Issues and Decisions

47-1

and other changes will be required to change this way of life. For example, if a government sets up a social security system to support the elderly, families might voluntarily have fewer children. Governments could offer people other incentives to limit their families. In China, the government urges couples to have only one child and offers economic and social rewards, such as better housing, to those that comply.

People in industrialized nations must also limit their population growth. Actually, most industrialized nations now have a lower rate of population growth than developing nations. Just as important, people in industrialized nations must simplify lifestyles to use fewer of the world's resources and waste much less. Limiting the destruction of the environment is as vital as limiting population.

Many other factors affect population control. Religious beliefs prevent some people from limiting the size of their families. Cultural beliefs, such as individual freedom, can also be factors. For example, many people believe that couples have the right to have as few or as many children as they wish.

Can people be convinced to voluntarily limit their children in time to escape the disasters of overpopulation and destruction of the environment? Will governments ever gain the power to impose a limit on the number of children a couple would be allowed to have? Would not forced population control mean a major loss of freedom? How can every country in the world be persuaded to agree to population control? These questions are just some of the ethical, moral, social, and political problems that population control could bring. If human beings do not choose to limit population growth, it is likely that nature will. The consequences of disease and starvation are frightening alternatives, however, to human efforts to solve the problem.

REVIEW *In the space provided, answer the questions following.*

1. What factors do demographers have to consider when they try to estimate how many people the earth can support?

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2. How might people in developing nations solve their present-day problems of insufficient food for heir growing populations? What help might they get from the industrialized nations?

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CONSIDER THIS *On a separate sheet of paper, answer the questions following.*

1. Discuss ways that the human population might be controlled so that human and environmental damage is kept to a minimum.

2. In your opinion, could these results be achieved voluntarily within a free society, or should people be forced to comply? Explain your opinion.

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Vita

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